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PREFACE AND INTRODUCTION OF RUSSIAN MONOGRAPH ON AUTOMATIC
MEASURED, CONTROLLING, AND REGULATING INSTRUMENTS

by I. V. Butusov

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PREFACE AND INTRODUCTION OF RUSSIAN MONOGRAPH ON AUTOMATIC
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Following is a translation of excerpts (Preface and Introduction) taken from the Russian-language monograph Avtomaticheskiye kontrol'-no-izmeritel'nyye i reguliruyushchiye pribory, Leningrad, State Scientific-Technical Publishing House of Literature on Petroleum and Mineral Fuel, 1958, pages 3-10. Author of the monograph is I. V. Butusov.

<u>Table of Contents</u>	<u>Page</u>
Preface	2
Introduction	3
Figure Appendix	7

PREFACE

As a result of the high rate of development of the Soviet instrument-making industry through the efforts of our scientists and engineers, many new instruments of high quality have been devised which surpass the newest foreign instruments in technical performance. An especially extensive development has been attained in the case of automatic comparators with balanced measuring circuits, which have permitted very accurate measurement and regulation of the quantity being controlled.

The rapid development of instrument manufacture and means of automation has created the necessary base for the extensive realization of the automation of technological processes in industry. The introduction of modern technological processes in the oil production and refining industries and their automation has led to the necessity of creating control and regulating devices based on the modern achievements of science and technology. The need for control and regulating devices in oil production and refining plants has increased significantly. Along with the pneumatic devices widely used in the oil industry, electronic instruments based on the application of radioisotopes, and of ultrasonic and electromagnetic waves, are much used. Long, uninterrupted operation of these devices can be guaranteed only when they are correctly and skillfully run.

Some of the knowledge concerning control and regulating devices as presently used in industry, including the oil industry, is assembled in this book.

In the book, the author gives descriptions of the basic elements of automatic instruments; states the principles of the operation and construction of measuring-controlling devices intended for the measurement of temperature, pressure, level, humidity, flow, heat content, etc.; and assembles characteristics and descriptions of the principles of the operation and construction of regulating mechanisms.

In the book, special attention is devoted to instruments for new fields. Also, some questions of the theory of control and regulating devices are elucidated to the extent necessary for an understanding of the materials discussed. General questions of placement, operation, testing, and trouble-shooting in certain instruments are examined.

Mainly considered in the book are the control and regulating devices of the State General Construction Bureau, the National Research Institute for Heat Instruments, the All-Union Heat Technology Institute imeni F. E. Dzerzhinskiy, the Central Automation Laboratory of the Ministry of Ferrous Metallurgy U.S.S.R., and others.

Of course the present book devoted as it is to an examination of different control and regulating devices, is not devoid of defects.

The author will be grateful to those readers who send critical comments and suggestions to the editor's address. The author extends his deepest thanks to comrades V. A. Romanov, Ye. M. Dushin, and A. A. Vavilov for the valuable comments made by them on reading the draft.

INTRODUCTION

Tasks of the Automation of Industrial Processes in the Petroleum Industry

The 20th Congress of the Communist Party of the Soviet Union, in the directives concerning the Sixth Five-Year Plan, specified that the petroleum industry should bring the yield of petroleum up to 135 million tons per year; increase the production of light oils by approximately 2 times; increase the production of lubricating oils by 1.8 times; increase the mean rate of oil and gas drilling in exploited wells not less than 85% and in test wells 95%; increase the output and production of gas according to the Five-Year Plan by approximately 3.9 times; raise the productivity of labor not less than 50%.

In order to fulfill the tasks set for the petroleum industry by the Sixth Five-Year Plan, it is necessary to make extensive use of measures for raising the technical level of production, which are based on the furthest possible development of electrification, all-out mechanization and automation, and introduction of the newest, most highly productive equipment and advanced technology.

A decisive role in effecting the fastest development of the national economy, particularly of the petroleum industry, is played by the automation of the productive processes.

Automation opens practically unlimited possibilities for a growth in labor productivity, elevates the culture of labor, curtails accidents, assures safety and rhythm in work, and reduces waste. Automation of production permits one to achieve economies in raw materials, fuel, energy, reagents, etc., which lead to sharp reductions in the cost of production.

In the Sixth Five-Year Plan for the development of the national economy during 1956-1960, it was specified that the petroleum industry should effect wide-scale mechanization and automation of lowering-and-raising operations during oil well drilling; automate the work of pumping and transporting oil; introduce extensive automation in the oil refineries being built; effect a gradual conversion to remote-control and centralized management of oil and wet drillings, and of oil and gas mains.

Solution of the problems attending the automation of the oil industry requires a large number of measuring instruments, regulators and control mechanisms, general industrial and special purpose devices. It also requires an expansion of their nomenclature, and the development of an entire line of instruments working on new physical principles and permitting one to perform remote measurements on groups of heat engineering parameters in the refineries.

In recent years the Soviet Union has introduced a line of instruments for measuring the pressure and vacuum, level, density, flow, and thickness of materials based on the application of radiations from

radioactive isotopes and of ultrasonic and electromagnetic waves. This makes possible the control of technical parameters without bringing the material to be measured outside the technological apparatus. The use of indirect methods of measurement and control affords instrument manufacturers new opportunities for improving instrument characteristics and extending significantly the ranges of the quantities to be measured.

Three Types of Automation of Industrial Processes

Automation may be tentatively divided into three types:

1. Automatic direction and regulation by means of separate parameters not dependent on one another.

2. Automatic direction and regulation by means of separate related parameters of the productive process.

3. Completely integrated automation of the productive processes.

The first type of automation consists mainly in the regulation of separate process parameters, such as level, pressure, flow of a liquid or a gas, temperature, etc.

In establishing automation of the first type it is necessary to label the control and regulating instruments extensively. In this case, it is desirable to have instruments with scales of good visibility which combine the measuring, recording, and regulating mechanisms in one chassis. Such instruments are usually called universal or basic construction instruments. Besides these, one also needs apparatus regulators, the layout of which is recorded or displayed separately from the regulating instrument. The instruments are mounted on a panel located close to the object being automated.

In establishing automation of the second type, the necessity arises of joining several regulators in a common system. A characteristic of this type of automation is the transition from basic construction to the building up of aggregates of automatic control and regulatory instruments. In this case, the regulatory system consists of interrelated standard units each performing a definite function. These units can be included at different places in the system. Direction is managed via instruments assembled on the control panel, and is established by the operator or dispatcher while he is following the course of the processes in the entire automated object. Already at this stage of automation, the question arises of reducing the number of instruments displayed on the panel or else of significantly reducing the sizes of the panel instruments. Together with this, the requirements regarding sensitivity and regulating precision are raised. In connection with the higher requirement regarding regulating precision, a much more extensive use is found for compensated methods of measurement, not only of electrical but also nonelectrical quantities.

The third type of automation is characterized by the conversion from the automation of separate processes to the complete automation of objects, (shops, plants, electric stations, etc.) and the extensive use of computing machines, permitting one to carry the regulating process to an optimum condition. Centralization of control leads to considerable

enlargement of the dimensions of control panels. Thus arises the necessity of complying the existing apparatus for the purpose of simplifying the process of control, reducing the number of service personnel, reducing the number of instruments on the control panels, and reducing the space occupied by the panels.

A display-control panel is a combination of a schematic diagram of the object with a control panel. Two basic types of display panels exist: graphical and combined. On the first type of panel, one depicts the basic elements of the object and the relationships between them. The panel is rigged with miniature instruments which are arranged in a mnemonic pattern corresponding to their actual locations in the object. The visible display of all elements of the object on graphic panels, with the instruments distributed on corresponding sites, significantly lightens the labor of the operator in directing complex objects.

In the combined type of panel, a part of the instruments is distributed outside of the schematic, at the side or above it, while only switches and pilot lamps are placed at corresponding sites of the schematic. In order to facilitate the process of centralized control, extensive use is made of signal mechanisms which signal when parameters exceed the assigned limits. When there are a large number of control points, one employs scanning (multi-switching) mechanisms, sequentially connecting the control instrument to all points.

Block Diagrams of Automatic Electronic Instruments and Regulating Mechanisms

At the present time, great quantities of automatic electronic instruments and regulating mechanisms of various designs are produced by the domestic industry. The operating principles of secondary automatic instruments and regulating mechanisms of basic design have been summarized for all varieties of design and presented in Figure 1. In the general case an automatic electronic instrument consists of a primary transducer (probe), a measuring circuit, an electronic amplifier, a reversible motor, a stabilizing mechanism, and a power supply. Depending on the purpose and type of instrument, each of the indicated units may have various schematic and constructional designs, but the block diagram remains basically the same. Certain units shown in the block diagram may sometimes be absent. Thus, for example, instruments are produced without regulating mechanisms or with rheostat controls, and a regulating mechanism is provided as a separate accessory.

A primary transducer (probe) serves to convert nonelectrical quantities into electrical ones and is generally located adjacent to the controlled object. Connection of a primary transducer with the measuring circuit of a secondary instrument is accomplished by means of a connecting cable.

The type of measuring circuit is determined by the probe which is working in the system with the instrument. The measuring and auxiliary probes, which serve to compensate for any disturbing effects of environmental factors.

In general, the electronic amplifier consists of a matching network, a voltage amplifier, and a power amplifier. In automatic instruments only A.C. amplifiers are used; these provide a very stable null.

The required dynamic properties are secured in the instruments with the aid of stabilizing mechanisms. These take the form of rate generators, differentiating and integrating circuits, etc.

Indicating and recording mechanisms generally consist of scales, indicating meters, tape recorders, and chart recorders.

Different regulating mechanisms are added as accessories to obtain regulation in automatic instruments.

In regulating mechanisms of the apparatus type, the recording and indicating mechanisms are separate from the regulating instrument. An apparatus type of regulating mechanism which acts indirectly is depicted by the block diagram shown in Figure 2. As is seen from the figure, a regulating mechanism includes the following elements: 1) a command mechanism, or commander; 2) a sensing element; 3) an amplifier-converter; 4) a feed-back loop; 5) a parametric tuner.

The command mechanism assigns the value of the regulated quantity which must be automatically maintained at a given level during the course of a technological process.

The sensing element perceives the departure of the regulated quantity from the given value and converts it into a proportional signal which serves as the input to the amplifier-converter.

The amplifier-converter effects a comparison of the signals received from the sensing element, the commander, and the feed-back loop and amplifies the resulting signal up to a size sufficient for actuating the control mechanism. If the control mechanism requires a conversion of the amplified signal, then the amplifier-converter also fulfills this function.

The feedback loop, which transmits an effect from the amplifier output to its input, serves to improve the dynamic characteristics of the regulating mechanism. In addition to the main feedback loop in the regulating mechanism, there may be local feedback loops which encompass special elements.

The tuner serves to vary the parameters of the regulating mechanism.

FIGURE APPENDIX

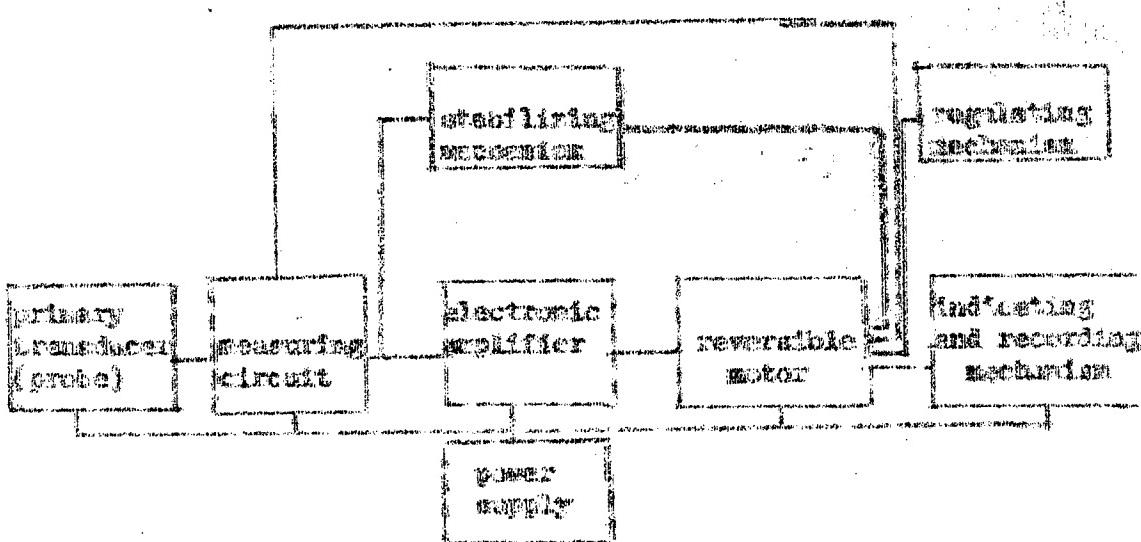


Figure 1. Block diagram of an automatic electronic instrument with regulating mechanism.

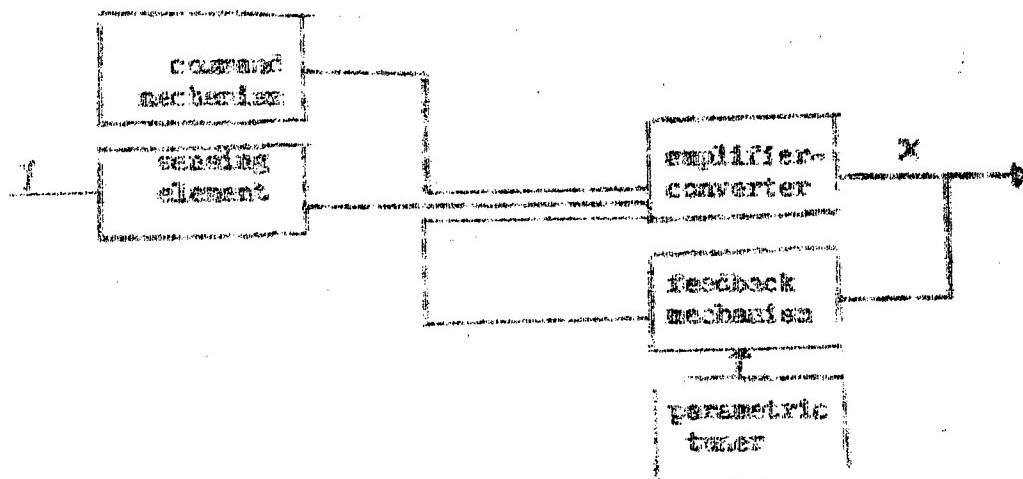


Figure 2. Block diagram of a regulating mechanism of the apparatus type.